GIS-Based Satellite Broadband Service Terrain-Shadow Modeling for Utah

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Please note: this is a draft document. Any comments or suggestions relating to methodology or outcome are greatly appreciated.

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To determine areas in the state where tremendous terrain relief can shadow various satellite broadband service signals we chose to investigate modeling options available within the ESRI ArcGIS software suite. While broadband was the major topic of concern, this analysis should apply to almost any geostationary satellite (including, we believe, the major satellite television systems).

The first option we investigated was the viewshed tool. Unfortunately we found that the ‘observer’ point for the viewshed needed to be within the extent of the digital elevation model (DEM) used to derive the viewshed and an observer point 23,000 miles in space would not work as it would mean, among other things, a prohibitively large area of data to make up the analysis area.

The other option we investigated was to create a hillshade in ArcMap (see comment at bottom of page for more details) from a 10 meter digital elevation model (DEM) with the option to model shadows. We utilized some trigonometry (figure 1, table 1 below) to approximate the angle the satellite signal would illuminate or intersect the center of the state for the hillshade tool’s Altitude parameter (angle of the illumination source above the horizon). For the Azimuth parameter (angular direction of the illumination source) we found a web page that tracks in real time all the geostationary satellites and computes the azimuth for each satellite relative to your current location.

The results showed many small, localized dead-zone or shadow areas as across the state (figure 2). The dead zones are isolated in areas like the canyons of Zion National Park and steep, north-facing slopes of the Wasatch mountains that are to the north of very steep hillsides/cliffs, some of which approach vertical relief.

However, after inspection of the data derived from ‘satellite shadow’ analysis results we were unable to find many structures affected by the shadows. This is not surprising as the locations in the satellite shadows tend to be steep, susceptible to rock, land, and/or snow slides, and receive little or no direct sunlight in the non-summer months.

One such affected structure is the Timpanogos Cave National Monument Visitors Center (in American Fork canyon). Figure 3 shows the satellite shadow areas for satellites at two geostationary orbit locations (but different longitudinal positioning along the equator. The Visitors Center parking lot appears to be out of the shadow area of one satellite but not the other. The Visitor’s Center building in the northern-most portion of the largest orange shape and would not be expected to be able to communicate with either satellite.

In conclusion, while this is a rather rough estimate of satellite service shadow areas, we feel that the precision of the elevation data is such that this gives us a sufficient view into the geographic dynamics of this technology. A more sophisticated approach could involve the use of LIDAR data to incorporate buildings in urban environments but urban buildings tend to exist in areas where numerous other broadband technology options, often with vastly superior performance and cost, are present. With very few exceptions, we feel that the assumption of statewide satellite availability is valid.

Figure 1, Sketch of the Trigonometry Involved to Solve for Horizon Angle of Geostationary Broadband Satellites

Table 1, Trig calculations for Figure 2 using an Observation Point of 39.5 degrees north (CLICK TO VIEW MS EXCEL FILE)

Figure 2, Approximation of Utah Satellite Service Dead Zones (based on 2 satellite positions)

Figure 3, Service Dead Zones for 2 Different Satellites at Timpanogos Cave National Monument Visitors Center